Managing Neutron Beam Scans at the Canadian Neutron Beam Centre

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Six beam lines:
- Powder Diffractometer
- Polarized Beam
- Triple-Axis Spectrometers
- Reflectometer
- Stress-Scanning Diffractometer

Ancillary equipment:
- Cryostats
- Furnaces
- Monochromaters
- Filters
- etc.

NRU: Canada’s multipurpose research reactor

Experiment Control

Sample space involves many independent variables:
• location, duration, magnetic fields, temperature, stress, background measurements, sample changes, beam focus, energy levels ....
• An experiment may involve scanning at thousands of points within the sample space.

During the experiment, scientists:
• Specify the points in sample space
• Sequence the points
• Run sequences of points
• Modify and rerun the sequences
• Organize the data into data sets for analysis
Experiment Control

Issues to address:

• Minimize the paradigm shift
  • There’s 30 years of experience in the current system
• Identical software on all beam lines
  • Differences between beam lines addressed through configuration mechanisms
• Low learning curve for the basic functionality
  • Many visiting scientists come for days/weeks
  • Must be able to work independently
Managing the scans...

• Formalize the concept of 'scan' using a basic algebra:
  • Scans defined in terms of set theory
  • Set of operators for building scans (sequence, dot product, multiply, interleave, ...)
  • e.g.,
    • \( \text{step}(Q, \ldots) \mid \text{bg}(\ldots) \)
    • \(((\text{step}(\text{PHI}, \ldots) \uparrow \text{m\_flip('up', 'down')} \uparrow \text{d\_flip('up')}) \ast \text{step}(\text{TEMP}, \ldots))\)

• Repository:
  • templates of commonly used scan types (stepping, background, texture, polarized scans...)
  • User defined templates
Managing the scans

• User database
  • One per experiment
  • Each record defines a scan
  • Records are constructed by instantiating templates and combining using scan algebra

• Execution sequence
  • Expression to select and sequence records from the scan database
  • Basic operators for sequencing, repeating, e.g.:
    • (5-30), 99*10, (50-40)
  • Organize the acquired data for analysis
Managing the scans

Scan template repository
• Templates of scanning techniques
• Common + user defined
• Relatively stable

Scan database
• One db per experiment
• Instantiate and combine templates
• Frequently modified, even during experiment

Scan Sequence
• Expression to select and sequence records from the database
• Organize acquired data
**Implementation**

- EPICS Based control system
- Identical system deployed on all beam lines
- Scan algebra implemented in the Python language:
  - Python operators redefined as scan algebra operators
- Repository:
  - Templates are parameterized Python functions
  - Users can build their own templates
- Database
  - Usually quite simple, spreadsheet suffices
  - Ability to add Python scripting
- GUI for selecting and sequencing records from the database
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• Questions?
  • ... and answers!